

# North Temperate Lakes Long Term Ecological Research

Lakes are integral to many landscapes throughout the world, but a wide range of human activities have altered the interactions between lakes and their surroundings. Humans, in turn, respond to these changes and the quality of life and the economies of a region will depend upon the quality of the lakes. The North Temperate Lakes LongTerm Ecological Research (NTL-LTER) program seeks to understand the long-term ecology of lakes and their interactions with terrestrial, atmospheric, and human processes, at multiple scales of space and time.



Our major goals are to:

- ◆ Perceive long-term changes in the physical, chemical, and biological properties of lakes.
- ◆ Understand the drivers of temporal variability in lakes and lake districts.
- ◆ Understand the interaction of spatial processes with long-term change.
- ◆ Understand causes and predictability of rapid, extensive change in ecosystems.
- ◆ Build a capacity to forecast the future ecology of lake districts.



Our research group currently includes ecologists, limnologists, biologists, hydrologists, geologists, chemists, sociologists, demographers, climatologists, and remote sensing and information management specialists. We welcome independent or collaborative research at our LTER field sites.

For more information see:

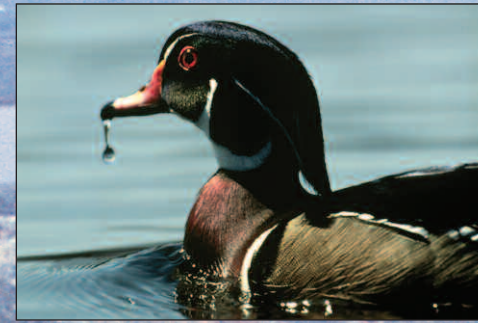
<http://lter.limnology.wisc.edu>

The North Temperate Lakes LTER is part of a coordinated network of research sites. For more information see:

<http://www.lternet.edu>



Cover Photos: (This page) Michael Rothbart. (Overleaf) Large lakes background: Carl Bowser. wood duck and turtle: Bob Korth; research raft: Tim Meinke; kids on raft: Pam Fashingbaun.



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## Long Term Ecological Research

**How do setting, climate, and changing land use and cover interact to shape lake characteristics and dynamics over time: now, in the past, and in the future?**

### Studying the Lakes in Time and Space

Since the early 1980s the NTL-LTER has collected data to address questions regarding the ecology and management of lakes from a long-term perspective at multiple scales—from an individual lake, to multiple lakes, and from districts to entire regions. We focus our data collection on two sets of lakes and their surrounding landscapes. One data set is in the forested and tourism-dominated Northern Highland Lake District in northern Wisconsin; the other is in the agricultural- and urban-dominated landscape in and near Madison in southern Wisconsin.

In northern Wisconsin, beginning in 1981, we focused on seven primary lakes and surrounding areas. This watershed is linked through a common groundwater and surface water flow system and shares a common climate and soil type. The set includes lakes of low to moderate plant and animal growth (productivity), that differ in size, shape, habitat types, temperature,

chemistry, biodiversity, and position in the groundwater flow system. In 1994, we also started collecting data at four high productivity lakes in southern Wisconsin, representing gradients in urban vs. agricultural land-use areas, and headwater vs. downstream



Invasive crayfish (*Orconectes rusticus*). Photo: J. Magnuson



Exotic rainbow smelt (*Osmerus mordax* Mitchell) Photo: J. Lyons

ecosystems. Substantial historical data are available for both of these northern and southern study sites, which help put the recent data in perspective.

Collectively, these two lake districts afford a unique opportunity for analyses of the Western Great Lakes region. These ecosystems and their gradients have allowed us to pioneer new ways of thinking about how aquatic systems are structured and function—from the role that their position in the landscape plays in constraining lake characteristics, to the interactions between socio-economics and human use (and abuse) of our aquatic resources.



School children collecting zooplankton. Photo: M. Woodford

### Exotic Species Research

In addition to providing comprehensive lake data, our sampling program allows us to assess invasions and impacts of exotic species. Potential new invaders include many European species that have reached the Laurentian Great Lakes region. These large lakes now act as a nearby source of colonists for a wide variety of organisms, including fishes, zooplankton, mollusks, invertebrates, macrophytes, and toxic algae. We have designed our sampling so that invasions of these or other species will be discovered early and we can implement specific research activities to understand the consequences of these introductions.

Our findings in this area highlight the many detrimental effects of exotic species, including the displacement of native populations by exotics, food web disruption, and loss of biodiversity. We work with both educational researchers and lake managers to inform K-12 students, through our active SchoolYard LTER program, as well as the general public about the potential threat of invasive species to aquatic ecosystems.

### Many Disciplines, Common Goals

Ecosystems are complex systems in which change occurs from multiple factors acting across a range of spatial and temporal scales. Disentangling cause and effect requires long-term monitoring, and we continue to build and use our long-term database. Our long-term research provides an opportunity for studying natural and human disturbances through analysis of regional variability, historic data, and both episodic and chronic events. We also use whole-lake experiments to help us understand how lakes respond to particular environmental changes. This interdisciplinary approach, which integrates economists and sociologists with ecologists and limnologists, will allow us to continue to make fundamental contributions to both the natural and social sciences. This work will inform future generations of scientists, managers, and lake lovers alike.

Spatially, we have developed a geographic information system that includes data layers on land use and land cover, soils, topography, roads, and other landscape features to provide basic information about the terrestrial landscapes surrounding our study lakes. We have a particularly strong foundation of spatial data from both satellites and aerial photos. Recently, the Wisconsin Satellite Lake Observatory Initiative (SLOI - [www.lakesat.org](http://www.lakesat.org)) has brought together scientists and lake managers from NTL-

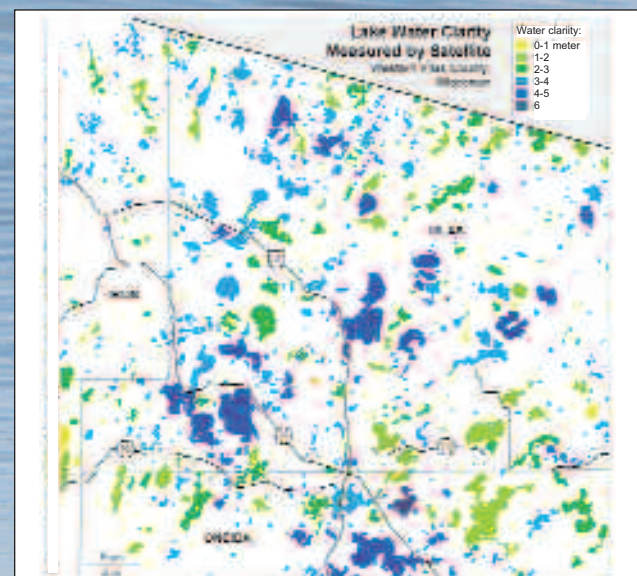
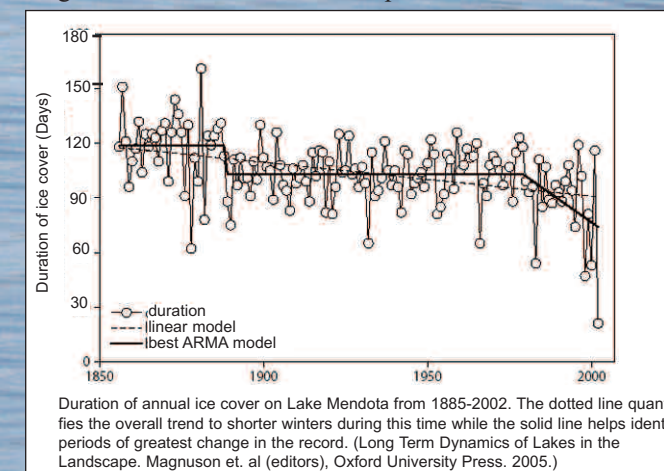


Image: Environmental Remote Sensing Center, Gaylord Nelson Institute of Environmental Studies, University of Wisconsin, Madison.

LTER, the Wisconsin Department of Natural Resources, and other organizations, with the goal of improving the use of satellite remote sensing for monitoring Wisconsin's numerous inland lakes. Using multispectral satellite imagery to predict water quality over large areas will lead to improvements in the application of remote sensing to the monitoring and management of inland waters of North America.

### The Value of Long-term Data: One Example

Each year lakes and rivers at northern latitudes freeze in autumn and breakup in spring. Observed once, these events lack context and reveal little information about the climate. We have assembled records of such events at sufficient regularity since the middle of the 1800s on lakes and rivers all around the northern latitudes, allowing us to draw significant inferences of change around the Northern Hemisphere.



What do these long-term, broad scale records tell us? First they tell us that at the NTL-LTER site, the ice duration on Lake Mendota in the winter of 1997-98 was the shortest over the period of record beginning in the 1850s. Also, the average duration of ice cover has declined from about four to about three months or by 25%. The long-term trend corresponds to a warming of about 1.8°C over 100 years.

These patterns are observable around the Northern Hemisphere with little variation (37 of 39 trends are in the direction of warming). The ability to infer long-term and regional patterns from these events puts the observations at one site in one year in a context more useful and meaningful to us as we attempt to deal with global change.



